ARIES-RS TRANSPORT MODELING

Transport modeling of the ARIES-RS plasma uses a multi-code strategy

1) A bootstrap aligned MHD equilibrium is found using TOQ

2) The ONETWO transport code is run in analysis mode to compute the fusion power for the equilibrium density and temperature profiles.

3) The GLF23 transport model is used (in a separate transport code) to find the steady state temperature profiles holding the density and sources fixed. The fusion power is reduced if needed to keep the pressure near the target beta.

4) The GLF23 temperature profiles are transferred to ONETWO and the fusion power is recomputed. The deuterium/tritium ratio is adjusted in order to match the fusion power reduction required to match beta.

5) Iteration between 3 and 4 proceeds until convergence is achieved.

COMMENTS ON THE GLF23 TRANPORT MODEL

The GLF23 transport model uses the linear instabilities of the gyro-Landau fluid equations. These equations approximate the full gyro-kinetic theory. The transport fluxes are computed from quasilinear theory with a mixing length model for the saturated fluctuation level. The fitting parameters of the model are all fit to kinetic linear theory and to non-linear simulations of ITG-TEM turbulence. No fitting to experiment has been done. Ten wavenumbers are used for the ITG-TEM modes and 10 for the ETG modes at high wavenumbers.

The GLF23 model reproduces the L-mode and H-mode profiles from the ITER database to within about 20%. This primarily tests the ITG-TEM transport.

The GLF23 model has not been compare to a large database of internal barrier discharges so the ETG mode, which determines the electron transport within the ITB, has not been extensively tested. It has been shown to be reasonable for a limited number of DIII-D discharges. The threshold level of ExB velocity shear needed to quench the ITG-TEM modes is taken from theory but has not been extensively tested in the GLF23 model.

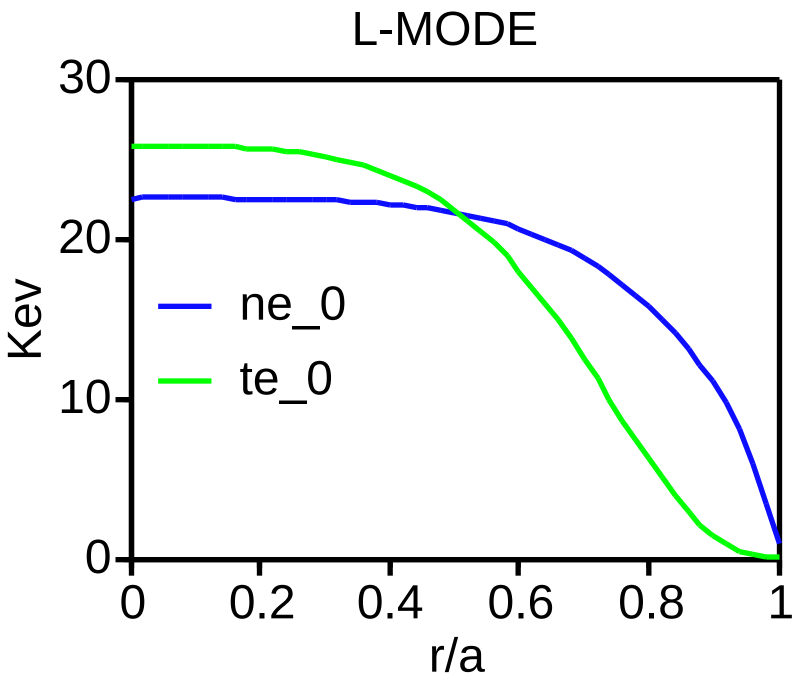
SUMMARY OF TRANSPORT RESULTS

	13.2MA Original	13.2MA Ne_Gw	8.27MA	8.27MA ITB
Ip MA	13.15	13.15	8.27	8.27
Iboot MA	10.00	8.07	6.70	7.94
I_{NBI} MA	0.59	1.87	1.42	1.47
Iohm MA	2.55	3.2	0.147	-1.15
Iboot/Ip %	76	61	81	96
Ne $10^{20}/m^3$	5.03	1.95	1.94	1.96
Ne/Ne_Gw	2.29	0.89	1.40	1.41
Pα MW	1,713	724	434	176
P_{rad} MW	280	280	271	217
Tau_e sec	0.51	1.36	1.10	1.98
H_{89p}	1.23	2.38	2.26	3.03
Beta_p	2.51	2.93	3.75	3.40
Beta_T %	6.65	7.78	4.03	3.66
Nd/Nt %	50	50	50	90

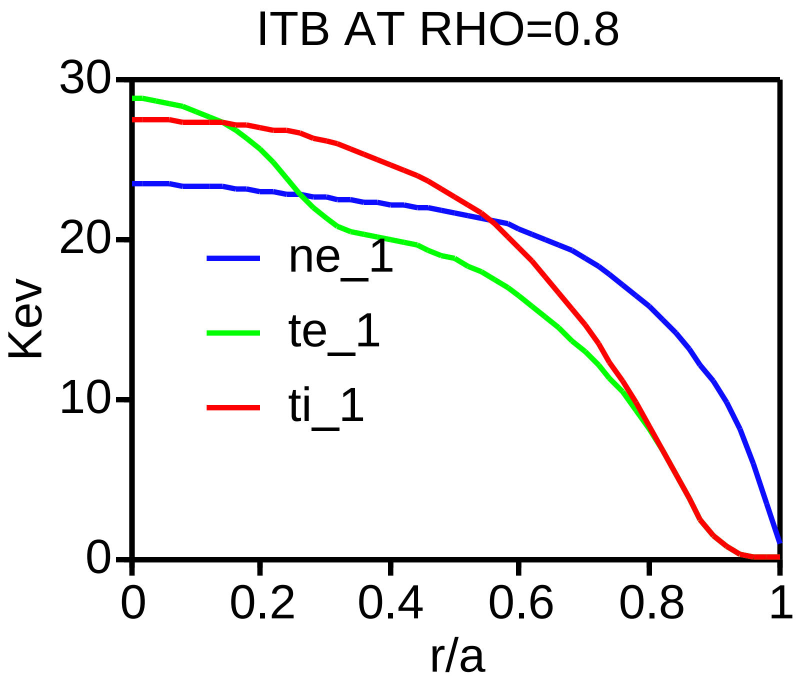
Common parameters:

Bt = 7.98T, R = 5.52m, a = 1.38m, P_{NBI} = 50MW

8.27MA BASE AND ITB TEMPERATURE PROFILES

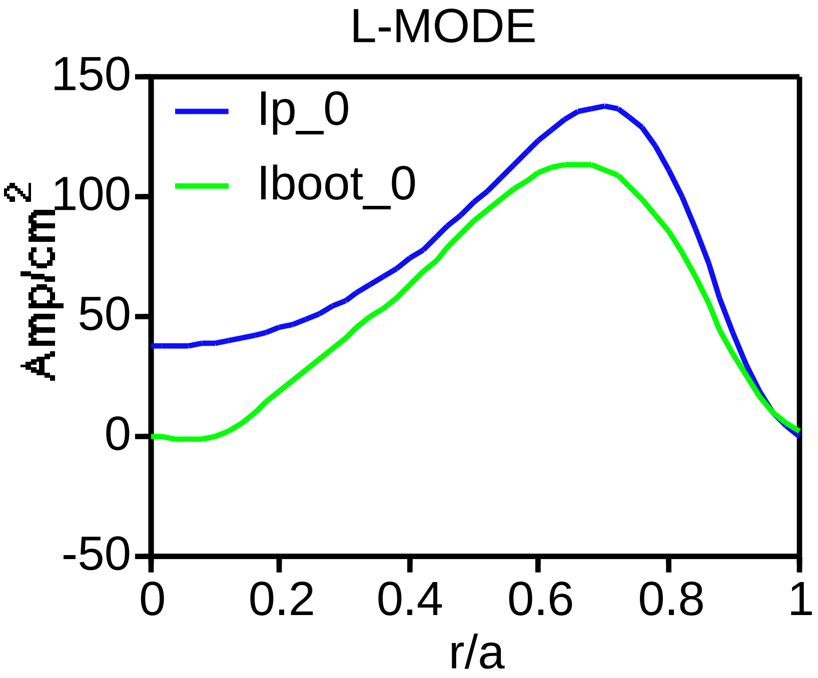


Ti = Te for the base case.

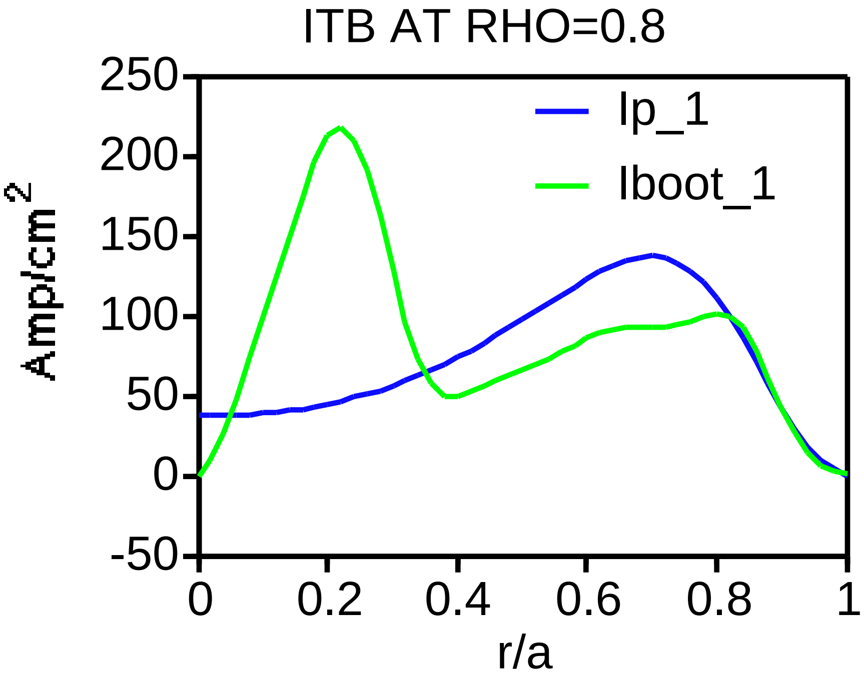


Transport is from GLF23 for ITB case.

8.27MA BASE AND ITB CURRENT PROFILES



Iboot/Ip = 81% for base



Iboot/Ip = 96% for ITB

COMMENTS ON THE ITB CASE

The large Shafranov shift and negative magnetic shear in the center of the plasma is stabilizing the ETG mode. This causes the electron temperature profile to steepen. This results in poor bootstrap alignment. A smaller central q would reduce this.

In NCS experiments with ITB's on DIII-D, the electron temperature profile is observed to be strongly flattened near the axis. The electron temperature gradient only follows the ETG mode threshold near the leading edge of the transport barrier. The cause of this flattening is not understood.

The high q in the core deteriorates the ion neoclassical energy confinement. Higher confinement should be possible at lower q and with a flatter q profile.

The deuterium/tritium ratio is unacceptably high (90%).

The line average density is still above the Greenwald limit ($ne/ne_{GW} = 1.41$)

WHERE DO WE GO FROM HERE?

The bootstrap alignment of the TOQ equilibrium is near optimum and cannot be expected to be much improved by the self-consistent transport modeling.

It is highly desirable to find a starting equilibrium with:
Iboot/Ip > 80%
H89p~2 consistent with ONETWO calculation of the fusion power
ne ~ Greenwald density

The Greewald density limit is $I/\pi a^2$

The TOQ equilibrium uses $T = p^{\sigma}$, $n = p^{(1-\sigma)}$, $\sigma = 0.8$ **for the present L-mode case.**

The bootstrap current goes up with n/T for a given pressure profile

$$n/T \sim n^2/\beta B^2 \sim f_{GW}(I/aB)^2/\beta a^2$$

Thus, at fixed β **and** $q \sim I/aB$ **it is necessary to reduce the size a to get to higher n/T.**